New Perspectives for Agricultural Biotechnology in Brazil

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In Brazil, the production of ethanol from sugar cane has increased 3-fold in the past 25 years. The current average yield is 6,000 L/ha. However, in line with the Kyoto Protocols, we will have to increase production at least 3-fold again by 2010 to satisfy projected needs.

Production of ethanol from sugar cane in Brazil results in an output of eight times more energy than is put in. In contrast, ethanol from corn kernels results in an energy output of 1.3–1.8 compared to 1.0 invested. We can produce up to 7,000 L/ha, which again compares favorably with corn kernels at 3,500 L/ha. Brazil also has greater sugarcane production at lower prices in comparison with Australia, South Africa, India and Cuba.

These advantages accrue from Brazil's geographical location and plentiful supply of rainfall, with ideal conditions of sunlight availability and temperature. Plenty of arable land is available and labor costs are low, which will contribute to increased production. Also we have scientific expertise in genetics and agriculture technology that has contributed to the increased productivity of sugar cane as a crop and improved efficiency of ethanol synthesis.

Need for Greater Productivity

However, even greater productivity will be needed to produce enough ethanol to meet global demands in the near future. One possibility is to use cane bagasse as a source of cellulose for fermentation to produce sugars and then ethanol. This will be similar to how corn starch is being used in the United States.

An alternative means of using cellulose to produce ethanol is to employ enzymes that can hydrolyze it for conversion to sugar. Bagasse, the residue after sugar extraction, is a good source of lignocellulosic material and a positive aspect is that it is already at the mill. There is no need to transport it for processing. Bagasse represents about 30% of the total biomass of sugar cane. Currently it is burned to produce steam for electricity.

Today, 1 ha yields 85 tons of cane that is mashed to produce juice. The juice is fermented to produce up to 7,200 L of ethanol. Including bagasse, this could be increased to 15,000 L/ha. Another 2-fold increase might be gained by breeding cane of higher fiber content, so-called "energy cane." Conventional cane produces around 70 to 120 tons/ha. High-fiber or energy cane might provide 140 to 240 tons/ha, doubling the yield of ethanol.

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New Biotech Companies

With these objectives in mind, two new companies were established in Brazil with the aid of venture capital. Allelyx, a plant-biotech company, was founded in 2002 by scientists at the Universities of Sao Paulo, Campinas, and Sao Paolo State who had sequenced the genome of *Xilella fastidiosa*, the causative agent of variegated chlorosis in citrus. CanaVialis is a sugar-cane breeding company, founded in 2003 by scientists at the Federal University of Sao Carlos. CanaVialis scientists, with over 30 years experience in sugar-cane breeding, have created the varieties that today make up over 60% of the sugar cane now planted in Sao Paulo state. These varieties are responsible for recent increases in sugar and ethanol productivity.

Allelyx is located at Campinas with about 130 employees, a third of whom are responsible for plant transformations. We are also strong in bioinformatic analyses with foci on sugar cane, citrus and eucalyptus. CanaVialis is using traditional breeding methods to generate new varieties of sugar cane; it has the world's largest breeding program for sugar cane. They have an experiment station with a huge stock of germplasm, close to the equator in a climate ideal for crossing cane varieties and maximizing breeding efficiency.

Allelyx provides the genes while CanaVialis provides the germplasm.

Allelyx deals with gene discovery, proof-of-concept and also with product development and regulatory issues, while CanaVialis works directly with producers to facilitate future commercialization of new varieties. In short, Allelyx provides the genes while CanaVialis provides the germplasm.

Proving Concepts

At this stage we are working mostly with model plants to prove concepts while developing protocols for efficiently transforming our target crops. We are leaders in terms of transformation protocols for sugar cane, citrus and eucalyptus, and have already proven some concepts in plant models:

- genes introduced in tomato and sugar cane increase sucrose content,
- sugar cane has been made resistant to the mosaic virus,
- lignin content in tobacco has been decreased, and
- xylem-bundle thickness and cellulose content in tobacco has been increased.

We are now working to introduce these traits to the target crops.

Some promising results have been obtained in terms of increasing sucrose content of sugar cane. Preliminary Brix data indicate that we have almost doubled it. Also, we have interesting results for drought tolerance in tobacco, which will be important for the expansion of sugar-cane production into the Cerrado, where rainfall is significantly less than in Sao Paulo to the south.

ana claudia rasera da silva is a biochemist with a PhD in molecular biology from the University of São Paulo (USP) and postdoctoral experience in molecular chaperones at the Rockefeller Laboratory of the Memorial Sloan Kettering Institute in New York. She worked for 8 years as assistant professor of biochemistry at USP, during which period she participated in the *Xylella fastidiosa* and *Leifsonia xyli* pv. xyli Genome Projects and coordinated the *Xanthomonas axonopodis* pv. citri Genome Project; the latter is the causative agent of citrus canker.

Dr. da Silva is one of the founders of Alellyx Applied Genomics, a Brazilian agricultural biotechnology company focused on sugar cane, *Eucalyptus* and *Citrus*, where she is responsible for the Citrus Program and the DNA Technology Department. Her team discovered and sequenced the causative agents of two citrus viral diseases: citrus sudden death and leprosis. Currently she is investigating ways of optimizing the vigor, productivity and yield quality of citrus groves.